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Exact solutions of the Navier-Stokes equations having steady vortex structures MARTIN Z. BAZANT, Mathematics, MIT, H.K. MOFFATT, DAMTP, Cambridge — We present two classes of exact solutions of the Navier-Stokes equations, which describe steady vortex structures with two-dimensional symmetry in an infinite fluid. The first is a class of similarity solutions obtained by conformal mapping of the Burgers vortex sheet to produce wavy sheets, stars, flowers and other vorticity patterns. The second is a class of non-similarity solutions obtained by continuation and mapping of the classical solution to steady advection-diffusion around a finite circular absorber in a two-dimensional potential flow, resulting in more complicated vortex structures that we describe as avenues, fishbones, wheels, eyes and butterflies. These solutions exhibit a transition from 'clouds' to 'wakes' of vorticity in the transverse flow with increasing Reynolds number. Our solutions provide useful test cases for numerical simulations, and some may be observable in experiments, although we expect instabilities at high Reynolds number. For example, vortex avenues may be related to counter-rotating vortex pairs in transverse jets, and they may provide a practical means to extend jets from dilution holes, fuel injectors, and smokestacks into crossflows.

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